PATENT ABSTRACTS OF JAPAN

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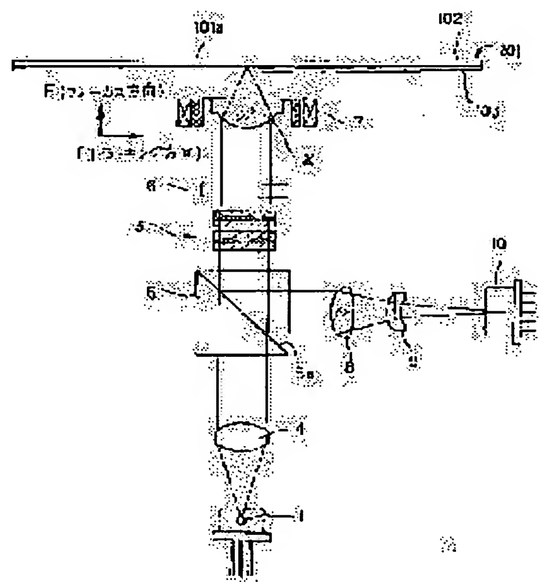
(54) OPTICAL PICKUP

(57)Abstract:
PROBLEM TO BE SOLVED: To correct the wave surface aberration caused by various errors when manufacturing an optical element, while suppressing the loss of light from the light source as much as possible, and correct especially the aberration due to thickness errors, slope errors of an optical recording medium.
SOLUTION: This liquid crystal element 3 has a light source 1, an objective lens 2 to condense the light flux from the light source 1 to irradiate the signal recording surface 101a of an optical recording medium 101, and a liquid crystal element 3 which has a front and a rear flat surface and is disposed in an optical path between the light sources 1, and the objective lens 2 to give a predetermined phase distribution to the transmitted light. It is built by sandwiching a liquid crystal molecule layer with a pair of transparent base plates whose sides facing the liquid crystal molecule layer are formed making the thickness distribution of the liquid crystal molecule layer similar to the phase distribution caused by the predetermined aberration.



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CLAIMS

[Claim(s)]
[Claim 1] The light source and the objective lens which condenses to the signal recording surface of an optical record medium, and irradiates at it the flux of light emitted from this light source, It is an optical pickup equipped with the liquid crystal device which is arranged into these light sources and the optical path between objective lenses, and a front **** front face is a flat surface, and gives predetermined phase distribution to the transmitted light. The field of the side which the above-mentioned liquid crystal device put the liquid crystal molecular layer, was constituted by the transparence substrate of a pair, and has sandwiched the above-mentioned liquid crystal molecular layer of each above-mentioned transparence substrate The optical pickup characterized by being the configuration which makes thickness distribution of this liquid crystal molecular layer the similarity configuration over phase distribution of the spherical aberration which produces a signal recording surface according to the thickness error of a wrap clear layer in an optical record medium.
[Claim 2] One side of the fields of the side which has sandwiched the liquid crystal molecular layer of each transparence substrate is an optical pickup according to claim 1 characterized by being a flat surface.
[Claim 3] The light source and the objective lens which condenses alternatively to one of two or more signal recording surfaces of a multilayer optical record medium, and irradiates the flux of light emitted from this light source, It is an optical pickup equipped with the liquid crystal device which is arranged into these light sources and the optical path between objective lenses, and a front **** front face is a flat surface, and gives predetermined phase distribution to the transmitted light. The field of the side which the above-mentioned liquid crystal device put the liquid crystal molecular layer, was constituted by the transparence substrate of a pair, and has sandwiched the above-mentioned liquid crystal molecular layer of each above-mentioned transparence substrate The optical pickup characterized by being the configuration which makes a selected signal recording surface which is different in thickness distribution of this liquid crystal molecular layer according to selection of the signal recording surface in a multilayer optical record medium the similarity configuration over phase distribution of the spherical aberration according to the thickness of a wrap clear layer.
[Claim 4] One side of the fields of the side which has sandwiched the liquid crystal molecular layer of each transparence substrate is an optical pickup according to claim 3 characterized by being a flat surface.
[Claim 5] The light source and the objective lens which condenses to the signal recording surface of an optical record medium, and irradiates at it the flux of light emitted from this light source, It is an optical pickup equipped with the liquid crystal device which is arranged into these light sources and the optical path between objective lenses, and a front **** front face is a flat surface, and gives predetermined phase distribution to the transmitted light. The field of the side which the above-mentioned liquid crystal device put the liquid crystal molecular layer, was constituted by the transparence substrate of a pair, and has sandwiched the above-mentioned liquid crystal molecular layer of each above-mentioned transparence substrate The optical pickup characterized by being the configuration which makes thickness distribution of this liquid

crystal molecular layer the similarity configuration over phase distribution of the comatic aberration produced with the inclination to the optical axis of the objective lens of an optical record medium.
[Claim 6] One side of the fields of the side which has sandwiched the liquid crystal molecular layer of each transparence substrate is an optical pickup according to claim 5 characterized by being a flat surface.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the optical pickup which constitutes account rec/play student equipments of optical, such as the so-called optical disc system, an optical MAG disc system, and an optical card system.
[0002]
[Description of the Prior Art] Conventionally, as an optical record medium, the optical disk like "CD (Compact Disc) (trademark)" and "DVD (Digital Versatile Disc)" (trademark) is proposed, and the optical pickup which performs the writing or read-out of an information signal to such an optical disk is proposed.
[0003] And in order to aim at increase of the storage capacity in such an optical disk in recent years, high NA(numerical aperture)-ization of the objective lens which makes short-wavelength-izing of the flux of light emitted from the light source in an optical pickup and this flux of light condense on the signal recording surface of an optical disk is performed.
[0004] For example, although it is 780nm in the optical pickup for "CD (trademark)" as luminescence wavelength of semiconductor laser (LD) used as the light source in an optical pickup, in the optical pickup for "DVD (trademark)" with more big storage capacity, it is 650nm. Moreover, although it is 0.45 in the optical pickup for "CD (trademark)" as numerical aperture (NA) of the objective lens of an optical pickup, in the optical pickup for "DVD (trademark)", it is 0.60.
[0005] Furthermore, when the objective lens of 0.85 is also proposed for 405nm (purple-blue color) semiconductor laser and numerical aperture (NA) and luminescence wavelength uses these for an optical pickup, further increase of the storage capacity of an optical disk will be achieved.
[0006]
[Problem(s) to be Solved by the Invention] By the way, if luminescence wavelength of semiconductor laser used as the light source is short-wavelength-ized as mentioned above and high NA-ization of an objective lens is attained, the effect to increase of the wave aberration in the optical system by various manufacture errors will become large. That is, wave aberration increases when a manufacture error is comparable, so that luminescence wavelength of semiconductor laser is short-wavelength-ized, and, so that an objective lens forms high NA. When the wave aberration in optical system increases, optical-character ability deteriorates and it becomes impossible to perform the good writing and good read-out of an information signal.
[0007] therefore — for example, in the optical pickup for the conventional "the DVD (trademark)", when a skew arises in an optical disk, the thing equipped with the device in which the relative inclination of an optical pickup and an optical disk is changed is proposed so that an optical axis may always be made perpendicular to the read side of this optical disk.
[0008] However, the various wave aberration generated in this way according to the manufacture error of the versatility of an optical element only in only adjusting the inclination to the optical disk of the whole optical pickup cannot be amended good, and wave aberration by a thickness error, an inclination error, etc. of an optical record medium cannot be amended especially good.

[0009] And as a configuration for amending the wave aberration in an optical pickup, various things are conventionally proposed by others. There are some which used the liquid crystal device for one of them. This is the configuration of inserting the liquid crystal device on the optical path between the light source and an objective lens, and giving desired phase distribution to the transmitted light by this liquid crystal device. Namely, this configuration gives a phase contrary to the wave aberration to generate beforehand to incident light by the liquid crystal device, and makes it non-aberration in an image formation side.
[0010] In a liquid crystal device, the substrate which puts a liquid crystal molecule usually consists of a flat-surface substrate of glass. The electrode for applying an electrical potential difference to liquid crystal is formed in this substrate. The liquid crystal molecule is located in a line along with the orientation film formed in the glass substrate, and is moved with the electrical potential difference impressed with the electrode formed in the substrate. Since ****** of the whole liquid crystal device changes with migration of such a liquid crystal molecule, it is possible to change the phase of the transmitted light of this liquid crystal device. And what is necessary is just to make distribution of voltage on the electrical potential difference impressed with an electrode, in order to give phase distribution to the transmitted light. Dividing and forming an electrode or more in at least two as an easy configuration for that is mentioned. By applying separately the electrical potential difference corresponding to desired phase distribution to the these-divided electrode, the distribution of voltage corresponding to the number of electrodes and applied voltage is formed, and it can obtain to the transmitted light of desired phase distribution in approximation. Of course, ideal phase distribution can be generated, so that the number of partitions of an electrode is made [many] and divided finely.
[0011] However, in such a liquid crystal device, as the number of partitions of an electrode is made [many], the area of the non-polar zone formed among electrodes becomes larger. And since ****** differ to the liquid crystal of the polar zone, the liquid crystal of the non-polar zone produces phenomena, such as diffraction of light, on a boundary with the liquid crystal of the polar zone, and it not only has a bad influence on image formation, but it causes [of the quantity of light] loss. In order to develop the life of semiconductor laser although the quantity of light loss by such the diffracted light does not pose a problem if allowances are in the power of the semiconductor laser used as the light source, little way of loss of the quantity of light in a liquid crystal device is good.
[0012] Then, this invention is proposed in view of the above-mentioned actual condition, and it tends to offer the optical pickup which can amend the wave aberration generated according to the various manufacture errors of an optical element good, and can also amend the aberration by a thickness error, an inclination error, etc. of an optical record medium good especially, suppressing loss of the light emitted from the light source as much as possible.
[0013]
[Means for Solving the Problem] The optical pickup which starts this invention in order to solve an above-mentioned technical problem is an optical pickup equipped with the light source, the objective lens which condenses to the signal recording surface of an optical record medium, and irradiates at it the flux of light emitted from this light source, and the liquid crystal device which is arranged into these light sources and the optical path between objective lenses, and a front **** front face is a flat surface, and gives predetermined phase distribution to the transmitted light. And a liquid crystal device puts a liquid crystal molecular layer, and is constituted by the transparence substrate of a pair, and the field of the side which has sandwiched the liquid crystal molecular layer of each transparence substrate is characterized by being the configuration which makes thickness distribution of this liquid crystal molecular layer the similarity configuration over phase distribution of the spherical aberration which produces a signal recording surface according to the thickness error of a wrap clear layer in an optical record medium.
[0014] In the optical pickup concerning this invention moreover, a liquid crystal device The field of the side which put the liquid crystal molecular layer, was constituted by the transparence substrate of a pair, and has sandwiched the above-mentioned liquid crystal molecular layer of each transparence substrate It is characterized by being the configuration which makes a

different selected signal recording surface according to selection of a signal recording surface [in / for thickness distribution of this liquid crystal molecular layer / a multilayer optical record medium] the similarity configuration over phase distribution of the spherical aberration according to the thickness of a wrap clear layer.

[0015] Furthermore, in the optical pickup concerning this invention, a liquid crystal device puts a liquid crystal molecular layer, is constituted by the transparence substrate of a pair, and is characterized by the field of the side which has sandwiched the above-mentioned liquid crystal molecular layer of each transparence substrate serving as a configuration which makes thickness distribution of this liquid crystal molecular layer the similarity configuration over phase distribution of the comatic aberration produced with the inclination to the optical axis of the objective lens of an optical record medium.

[0016] In the optical pickup concerning such this invention, it is continued and formed in the whole surface at the transparence substrate of the pair which puts a liquid crystal molecular layer, without dividing an electrode. And a uniform electrical potential difference is impressed to this electrode. That is, phase distribution of the transmitted light is decided by thickness of the liquid crystal molecule to penetrate.

[0017] Thus, in the optical pickup concerning this invention, since the electrode in a liquid crystal device is not divided, loss of the amount of transmitted lights by diffraction etc. is not invited.

[0018] Moreover, since phase distribution of the transmitted light of this liquid crystal device is decided by the optical path length who penetrates a liquid crystal device, it is decided by thickness distribution of liquid crystal. Since thickness distribution of liquid crystal is decided by the configuration of a transparence substrate, if the similarity configuration over desired phase distribution can be formed in the front face of a transparence substrate, it will become possible [giving phase distribution ideal for the transmitted light].

[0019]

[Embodiment of the Invention] It explains to a detail, referring to a drawing about the gestalt of concrete operation of this invention hereafter.

[0020] The optical pickup concerning this invention is equipped with the liquid crystal device 3 arranged into the optical path between the objective lens 2 which condenses to signal recording surface 101a of the optical disk 101 which is an optical record medium, and irradiates at it the semiconductor laser 1 used as the light source, and the flux of light emitted from this semiconductor laser 1, and these semiconductor laser 1 and an objective lens 2 as shown in drawing 1 .

[0021] The laminating of a base material 102 and the protective layer 103 is carried out, an optical disk 101 is constituted, and the field which is a front face of a base material 102 and was covered with the protective layer 103 has become signal recording surface 101a. The flux of light from an optical pickup penetrates a protective layer 103, and is irradiated by signal recording surface 101a. A front **** front face is a flat surface, and a liquid crystal device 3 gives predetermined phase distribution to the transmitted light so that it may mention later.

[0022] In this optical pickup, the flux of light which is the linearly polarized light emitted from semiconductor laser 1 is collimated by the collimator lens 4, and serves as a plane wave. Incidence of this plane wave is carried out to a beam splitter 5. This plane wave serves as P polarization to reflector 5a of a beam splitter 5, penetrates this reflector 5a, and penetrates a liquid crystal device 3. And this plane wave is made with the circular polarization of light through the quarter wavelength (lambda/4) plate 6, and results in an objective lens 2. This objective lens 2 condenses and irradiates the flux of light by which incidence was carried out at signal recording surface 101a of an optical disk 101.

[0023] the direction of tracking (direction which intersects perpendicularly with the optical axis of an objective lens 2) which shows an objective lens 2 by the direction of a focus (the direction of an optical axis of an objective lens 2) shown by the drawing 1 Nakaya mark F with the biaxial actuator 7, and the drawing 1 Nakaya mark T — migration — it is supported operational. Focusing adjustment and tracking adjustment are performed by actuation of this biaxial actuator 7.

[0024] And it is reflected by this signal recording surface 101a, and the flux of light condensed by signal recording surface 101a of an optical disk 101 serves as outward trip light and the circular polarization of light of an opposite direction, serves as the linearly polarized light of the direction which intersects perpendicularly in the polarization direction of outward trip light through an objective lens 2 and the quarter wavelength (lambda/4) plate 6, penetrates a liquid crystal device 3, and returns to a beam splitter 5. In this beam splitter 5, since the light which returned from the optical disk 101 is S polarization to reflector 5a of this beam splitter 5, it is reflected by this reflector 5a. It converges with the detection lens 8 and the flux of light reflected in the beam splitter 5 is received by the photodetector 10 through the multi-lens 9. The multi-lens 9 is a lens with which plane of incidence was made with the cylinder side, and the outgoing radiation side was made with the concave surface.
[0025] In this optical pickup, a liquid crystal device 3 gives predetermined phase distribution which erases the aberration produced in signal recording surface 101a about the flux of light irradiated by signal recording surface 101a inside to transmitted light flux.
[0026] That is, the phase distribution which a liquid crystal device 3 should give to the transmitted light turns into the phase distribution of wave aberration and the distribution of reversed polarity in the optical spot by which image formation was carried out on signal recording surface 101a with the objective lens 2.
[0027] For example, aberration to amend considers the case where it is what is depended on the thickness error dt and Skew theta of a protective layer 103 of an optical disk 101. Spherical aberration and Skew theta generate [error / dt / thickness] comatic aberration. Each aberration of a low degree is given by the degree type about aberration, and effect becomes large, so that the numerical aperture (NA) of an objective lens 2 is large and the wavelength of the flux of light emitted from semiconductor laser 1 is short.
[0028] That is, the 3rd spherical-aberration multiplier is given by the degree type.
[0029]
W40=dt/8x(n2-1)/n3xNA4 and the 3rd comatic-aberration multiplier are given by the degree type.
[0030] W31=t/2x(n2-1) xn2xsin thetaxcos theta/(n2-sin2theta)5/2xNA3 (**t: thickness of the protective layer of an optical disk)
(**dt: Thickness error of the protective layer of an optical disk)
(**n: ****** of the protective layer of an optical disk)
(**theta: Inclination of an optical disk)
A degree type will be obtained if such aberration is expressed with the coordinate (x y) standardized in the pupil radius on the pupil surface of an objective lens 2.
[0031]
3rd spherical aberration w(x y) =w40(x2+y2) 2 .... (formula 1)
3rd comatic aberration w(x y) =w31x (x2+y2) .... (formula 2)
Numerical aperture (NA) of an objective lens 2 cannot express the phase distribution corresponding to aberration sufficiently correctly only by the aberration of a low degree, when large. High order aberration is given by the degree type.
[0032] That is, the 5th spherical-aberration multiplier is given by the degree type.
[0033] W60=dt/48x(n2-1) x(n2+3)/n5xNA6 and the 5th comatic-aberration multiplier are given by the degree type.
[0034] W51=t/8x(n2-1) xn2xsinthetaxcostheta/(n2-sin2theta) 9/2xNA5x (n4+(3cos2theta-5sin2theta) n2+4sin2theta-sin4theta)
A degree type will be obtained if such aberration is expressed with the coordinate (x y) standardized in the pupil radius on the pupil surface of an objective lens 2.
[0035]
5th spherical aberration w(x y) =w60(x2+y2) 3 .... (formula 3)
5th comatic aberration w(x y) =w51x(x2+y2)2 .... (formula 4)
However, since the effect which gives high order aberration practically near the spot center of the light condensed with the objective lens 2 is very small, there is also little effect which it has on record playback of an optical disk. Therefore, the aberration which should be amended is

enough if only the aberration of a low degree is taken into consideration.
[0036] And as shown in drawing 2 and drawing 3 , a liquid crystal device 3 puts the liquid crystal molecular layer 13, and consists of two glass substrates 11 and 12 which are transparence substrates of a pair. Plane of incidence, an outgoing radiation side, i.e., a front face, and a rear face are made with a flat surface, and this liquid crystal device 3 is constituted. And in this liquid crystal device 3, thickness distribution of the liquid crystal layer 13 is made with the similarity configuration over phase distribution to give to the transmitted light of this liquid crystal device 3. Namely, one side is made with a flat surface and, as for the fields 11a and 12a whose liquid crystal layers 13 each glass substrates 11 and 12 countered mutually, and are pinched, another side is made with the similarity configuration over desired phase distribution.
[0037] In this liquid crystal device 3, as shown in drawing 4 and drawing 5 , it continues all over the fields 11a and 12a where each glass substrates 11 and 12 counter mutually, and one electrodes 14 and 15 are formed, respectively. Furthermore, the orientation film 16 and 17 is formed on these electrodes 14 and 15. The liquid crystal molecule of the liquid crystal layer 13 is located in a line along with the orientation film 16 and 17. As shown in drawing 4 , in the electrode 14 and the condition that the electrical potential difference is not impressed among 15, orientation of these liquid crystal molecule is carried out considering the direction of a major axis as parallel to the fields 11a and 12a of glass substrates 11 and 12. And these liquid crystal molecule will move to the condition of making the direction of a major axis perpendicular to the fields 11a and 12a of glass substrates 11 and 12, if an electrical potential difference is impressed between an electrode 14 and 15 as shown in drawing 5 . The refractive indexes of the liquid crystal layer 13 differ by the case where the polarization direction of incident light is in agreement in the direction of a major axis of a liquid crystal molecule, and the case where the polarization direction of incident light is not in agreement in the direction of a major axis of a liquid crystal molecule. Here, the direction of a major axis of a liquid crystal molecule is parallel to the fields 11a and 12a of glass substrates 11 and 12, and the refractive index of the liquid crystal layer 13 when the polarization direction of incident light is in agreement in the direction of a major axis of a liquid crystal molecule is set to n1. Moreover, the refractive index of the liquid crystal layer 13 when the direction of a major axis of a liquid crystal molecule is perpendicular to the fields 11a and 12a of glass substrates 11 and 12 is set to n2. And in the condition that the direction of a major axis of a liquid crystal molecule is slanting to the fields 11a and 12a of glass substrates 11 and 12, the refractive index of the liquid crystal layer 13 serves as a value between n1 and n2 according to the include angle of a liquid crystal molecule.
[0038] When there is no need of giving phase distribution to the transmitted light of a liquid crystal device 3, namely, when there is no manufacture error in this optical pickup and optical disk 101 and it is non-aberration in respect of image formation, the electrode 14 of a liquid crystal device 3 and the electrical potential difference impressed among 15 are adjusted, and it is made for the refractive index of the liquid crystal layer 13 to become equal to the refractive index n3 of each glass substrates 11 and 12 in this optical pickup, as shown in drawing 6 .
[0039] And as shown in drawing 7 , ****** of the liquid crystal layer 13 is changed by changing an electrode 14 and the electrical potential difference impressed among 15 to give phase distribution to the transmitted light of a liquid crystal device 3.
[0040] Phase distribution of the transmitted light of a liquid crystal device 3 is decided by the optical path length in a liquid crystal device 3. That is, phase distribution of the transmitted light of a liquid crystal device 3 is decided by the product (d (x) -deltan) of thickness distribution [of the liquid crystal layer 13] d (x), and ******** deltan between the liquid crystal layer 13 and each glass substrate 11, and 12. Therefore, similar phase distribution can be given to the transmitted light of a liquid crystal device 3 to thickness distribution of the liquid crystal layer 13 by changing an electrode 14 and the electrical potential difference impressed among 15, and producing ******** deltan between the liquid crystal layer 13 and each glass substrate 11, and 12.
[0041] A wave front when having produced spherical aberration turns into a wave front which phase contrast has produced in the center section and periphery of the flux of light, as shown in drawing 8 . Moreover, a wave front when having produced comatic aberration turns into a wave

front which phase contrast is producing gradually in the 1 side [flux of light] and side side else, as shown in drawing 9 . Therefore, it becomes non-aberration, when giving these phase distribution and phase distribution of reversed polarity beforehand to the wave front of the transmitted light of a liquid crystal device 3 and image formation is carried out with an objective lens 2.

[0042] Therefore, in order to amend spherical aberration, thickness distribution of the liquid crystal layer 13 in a liquid crystal device 3 is made into the configuration shown with the above (formula 1) as shown in drawing 10 . Moreover, in order to amend comatic aberration, thickness distribution of the liquid crystal layer 13 in a liquid crystal device 3 is made into the configuration shown with the above (formula 2) as shown in drawing 11 .

[0043] And you may arrange in piles in the optical path which faces each to an objective lens 2 as the liquid crystal device for amending the liquid crystal device and comatic aberration for amending such spherical aberration as shown in drawing 1 , or only either may be arranged. The sequence piled up when arranging in piles the liquid crystal device which amends spherical aberration, and the liquid crystal device which amends comatic aberration may be any, and may pile any up as a side near an objective lens 2.

[0044] In addition, in this optical pickup, even if thickness distribution of the liquid crystal layer 13 in a liquid crystal device 3 is not the configuration of similarity in phase distribution of spherical aberration or comatic aberration, amendment of aberration is possible. For example, since focus servo actuation according to the 2 shaft actuator 7 also as a configuration corresponding to the phase distribution to which the aberration by defocusing was added to spherical aberration amends a defocused part, amendment of aberration can be performed. However, since what is necessary is just to give phase distribution of reversed polarity about the phase distribution and the amplitude by the aberration itself in order for there to be no semantics in making it such a configuration not much and to attain amendment of aberration by the minimum phase correction, the configuration shown in the above drawing 10 and drawing 11 is the optimal.

[0045] Moreover, this invention is effective also in the optical pickup used to the so-called multilayer disk. In a multilayer disk, since the transparent protective layer intervenes between each side of two or more signal recording surfaces by which the laminating was carried out, for every signal recording surface, the thickness from the front face of an optical disk differs, and the spherical aberration to generate differs.

[0046] For example, in the case of "DVD (trademark)", the two-layer disk is adopted, spherical aberration sets up two-layer spacing as range permitted, and the optical pickup is designed, and does not have especially the amendment device of spherical aberration.

[0047] However, when you want to increase a signal recording surface further from two-layer in "DVD (trademark)", or when numerical aperture (NA) of an objective lens is enlarged even if it is two-layer, nonpermissible big spherical aberration occurs.

[0048] In order to reduce spherical aberration, it can think that what is necessary is to be thin in between layers, namely, just to make signal recording surfaces approach, but when between layers is made thin, while performing record and playback about a certain signal recording surface, the stray light from other signal recording surfaces returns to an optical pickup, and exact record and playback become here, impossible. Therefore, there is a limitation in making between layers thin. This limitation changes with designs of a system, luminescence wavelength of the light source, etc. including optical system. However, when the lower limit of the interlayer spacing from which the stray light from other signal recording surfaces does not pose a problem has exceeded the upper limit of the interlayer spacing which can permit spherical aberration, it is necessary to amend spherical aberration efficiently with a certain means.

[0049] Then, if it is going to amend spherical aberration using the conventional liquid crystal device which has the divided electrode, since only approximation-amendment can be performed, residual aberration is large and big spherical aberration [as / in a multilayer disk] cannot be amended. Moreover, by generating a spherical wave and making it put to an objective lens ON, only approximation-amendment can be performed, and since residual aberration is large, big spherical aberration in a multilayer disk cannot be amended.

[0050] Since amendment of the spherical aberration in this invention amends the change of the configuration of the wave front by spherical aberration itself to it, when amending the big spherical aberration generated when using a multilayer disk, little good amendment of residual aberration can be performed.
[0051] In addition, in the gestalt of operation mentioned above, although considered as the configuration of similarity in phase distribution of a request of one configuration of the fields of the glass substrate whose liquid crystal layer is pinched in the liquid crystal device, this invention is good for phase distribution of a request of the configuration of both sides of the field of the glass substrate not only this but whose liquid crystal layer is pinched also as a similar configuration.
[0052] Namely, since phase distribution to give the transmitted light of a liquid crystal device is decided by the product (d (x) -deltan) of thickness distribution [of the liquid crystal layer put with the glass substrate] d (x), and a liquid crystal layer and ******** deltan between each glass substrate, it does not depend on the configuration of a glass substrate, but thickness distribution of a liquid crystal layer has just become an analog to desired phase distribution.
[0053] Moreover, the field configuration of the field which puts the liquid crystal layer of each glass substrate may form a predetermined field configuration for example, with an ultraviolet-rays (UV) curing agent, and may form it by sticking this on a plane glass substrate.
[0054]
[Effect of the Invention] As mentioned above, the optical pickup concerning this invention The light source and the objective lens which condenses to the signal recording surface of an optical record medium, and irradiates at it the flux of light emitted from this light source, It is an optical pickup equipped with the liquid crystal device which is arranged into these light sources and the optical path between objective lenses, and a front **** front face is a flat surface, and gives predetermined phase distribution to the transmitted light. A liquid crystal device A liquid crystal molecular layer is put, it is constituted by the transparence substrate of a pair, and the field of the side which has sandwiched the liquid crystal molecular layer of each transparence substrate is characterized by being the configuration which makes thickness distribution of this liquid crystal molecular layer the similarity configuration over the phase distribution by predetermined aberration.
[0055] And in this optical pickup, it is continued and formed in the whole surface at the transparence substrate of the pair which puts a liquid crystal molecular layer, without dividing an electrode. And a uniform electrical potential difference is impressed to this electrode. That is, phase distribution of the transmitted light is decided by thickness of the liquid crystal molecule to penetrate.
[0056] Thus, in the optical pickup concerning this invention, since the electrode in a liquid crystal device is not divided, loss of the amount of transmitted lights by diffraction etc. is not invited.
[0057] Moreover, since phase distribution of the transmitted light of this liquid crystal device is decided by the optical path length who penetrates a liquid crystal device, it is decided by thickness distribution of liquid crystal. Since thickness distribution of liquid crystal is decided by the configuration of a transparence substrate, if the similarity configuration over desired phase distribution can be formed in the front face of a transparence substrate, it will become possible [giving phase distribution ideal for the transmitted light].
[0058] That is, this invention can offer the optical pickup which can amend the wave aberration generated according to the various manufacture errors of an optical element good, and can also amend the aberration by a thickness error, an inclination error, etc. of an optical record medium good especially, suppressing loss of the light emitted from the light source as much as possible.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates to the optical pickup which constitutes account rec/play student equipments of optical, such as the so-called optical disc system, an optical MAG disc system, and an optical card system.

[Translation done.]

PRIOR ART

[Description of the Prior Art] Conventionally, as an optical record medium, the optical disk like "CD (Compact Disc) (trademark)" and "DVD (Digital Versatile Disc)" (trademark) is proposed, and the optical pickup which performs the writing or read-out of an information signal to such an optical disk is proposed.
[0003] And in order to aim at increase of the storage capacity in such an optical disk in recent years, high NA(numerical aperture)-ization of the objective lens which makes short-wavelength-izing of the flux of light emitted from the light source in an optical pickup and this flux of light condense on the signal recording surface of an optical disk is performed.
[0004] For example, although it is 780nm in the optical pickup for "CD (trademark)" as luminescence wavelength of semiconductor laser (LD) used as the light source in an optical pickup, in the optical pickup for "DVD (trademark)" with more big storage capacity, it is 650nm. Moreover, although it is 0.45 in the optical pickup for "CD (trademark)" as numerical aperture (NA) of the objective lens of an optical pickup, in the optical pickup for "DVD (trademark)", it is 0.60.
[0005] Furthermore, when the objective lens of 0.85 is also proposed for 405nm (purple-blue color) semiconductor laser and numerical aperture (NA) and luminescence wavelength uses these for an optical pickup, further increase of the storage capacity of an optical disk will be achieved.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] As mentioned above, the optical pickup concerning this invention, The light source and the objective lens which condenses to the signal recording surface of an optical record medium, and irradiates at it the flux of light emitted from this light source, It is an optical pickup equipped with the liquid crystal device which is arranged into these light sources and the optical path between objective lenses, and a front **** front face is a flat surface, and gives predetermined phase distribution to the transmitted light. A liquid crystal device A liquid crystal molecular layer is put, it is constituted by the transparence substrate of a pair, and the field of the side which has sandwiched the liquid crystal molecular layer of each transparence substrate is characterized by being the configuration which makes thickness distribution of this liquid crystal molecular layer the similarity configuration over the phase distribution by predetermined aberration.
[0055] And in this optical pickup, it is continued and formed in the whole surface at the transparence substrate of the pair which puts a liquid crystal molecular layer, without dividing an electrode. And a uniform electrical potential difference is impressed to this electrode. That is, phase distribution of the transmitted light is decided by thickness of the liquid crystal molecule to penetrate.
[0056] Thus, in the optical pickup concerning this invention, since the electrode in a liquid crystal device is not divided, loss of the amount of transmitted lights by diffraction etc. is not invited.
[0057] Moreover, since phase distribution of the transmitted light of this liquid crystal device is decided by the optical path length who penetrates a liquid crystal device, it is decided by thickness distribution of liquid crystal. Since thickness distribution of liquid crystal is decided by the configuration of a transparence substrate, if the similarity configuration over desired phase distribution can be formed in the front face of a transparence substrate, it will become possible [giving phase distribution ideal for the transmitted light].
[0058] That is, this invention can offer the optical pickup which can amend the wave aberration generated according to the various manufacture errors of an optical element good, and can also amend the aberration by a thickness error, an inclination error, etc. of an optical record medium good especially, suppressing loss of the light emitted from the light source as much as possible.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] By the way, if luminescence wavelength of semiconductor laser used as the light source is short-wavelength-ized as mentioned above and high NA-ization of an objective lens is attained, the effect to increase of the wave aberration in the optical system by various manufacture errors will become large. That is, wave aberration increases when a manufacture error is comparable, so that luminescence wavelength of semiconductor laser is short-wavelength-ized, and, so that an objective lens forms high NA. When the wave aberration in optical system increases, optical-character ability deteriorates and it becomes impossible to perform the good writing and good read-out of an information signal.
[0007] therefore — for example, in the optical pickup for the conventional "the DVD (trademark)", when a skew arises in an optical disk, the thing equipped with the device in which the relative inclination of an optical pickup and an optical disk is changed is proposed so that an optical axis may always be made perpendicular to the read side of this optical disk.
[0008] However, the various wave aberration generated in this way according to the manufacture error of the versatility of an optical element only in only adjusting the inclination to the optical disk of the whole optical pickup cannot be amended good, and wave aberration by a thickness error, an inclination error, etc. of an optical record medium cannot be amended especially good.
[0009] And as a configuration for amending the wave aberration in an optical pickup, various things are conventionally proposed by others. There are some which used the liquid crystal device for one of them. This is the configuration of inserting the liquid crystal device on the optical path between the light source and an objective lens, and giving desired phase distribution to the transmitted light by this liquid crystal device. Namely, this configuration gives a phase contrary to the wave aberration to generate beforehand to incident light by the liquid crystal device, and makes it non-aberration in an image formation side.
[0010] In a liquid crystal device, the substrate which puts a liquid crystal molecule usually consists of a flat-surface substrate of glass. The electrode for applying an electrical potential difference to liquid crystal is formed in this substrate. The liquid crystal molecule is located in a line along with the orientation film formed in the glass substrate, and is moved with the electrical potential difference impressed with the electrode formed in the substrate. Since ****** of the whole liquid crystal device changes with migration of such a liquid crystal molecule, it is possible to change the phase of the transmitted light of this liquid crystal device. And what is necessary is just to make distribution of voltage on the electrical potential difference impressed with an electrode, in order to give phase distribution to the transmitted light. Dividing and forming an electrode or more in at least two as an easy configuration for that is mentioned. By applying separately the electrical potential difference corresponding to desired phase distribution to the these-divided electrode, the distribution of voltage corresponding to the number of electrodes and applied voltage is formed, and it can obtain to the transmitted light of desired phase distribution in approximation. Of course, ideal phase distribution can be generated, so that the number of partitions of an electrode is made [many] and divided finely.
[0011] However, in such a liquid crystal device, as the number of partitions of an electrode is made [many], the area of the non-polar zone formed among electrodes becomes larger. And since ****** differ to the liquid crystal of the polar zone, the liquid crystal of the non-polar zone

produces phenomena, such as diffraction of light, on a boundary with the liquid crystal of the polar zone, and it not only has a bad influence on image formation, but it causes [of the quantity of light] loss. In order to develop the life of semiconductor laser although the quantity of light loss by such the diffracted light does not pose a problem if allowances are in the power of the semiconductor laser used as the light source, little way of loss of the quantity of light in a liquid crystal device is good.

[0012] Then, this invention is proposed in view of the above-mentioned actual condition, and it tends to offer the optical pickup which can amend the wave aberration generated according to the various manufacture errors of an optical element good, and can also amend the aberration by a thickness error, an inclination error, etc. of an optical record medium good especially, suppressing loss of the light emitted from the light source as much as possible.

[Translation done.]

MEANS

[Means for Solving the Problem] The optical pickup which starts this invention in order to solve an above-mentioned technical problem is an optical pickup equipped with the light source, the objective lens which condenses to the signal recording surface of an optical record medium, and irradiates at it the flux of light emitted from this light source, and the liquid crystal device which is arranged into these light sources and the optical path between objective lenses, and a front **** front face is a flat surface, and gives predetermined phase distribution to the transmitted light. And a liquid crystal device puts a liquid crystal molecular layer, and is constituted by the transparence substrate of a pair, and the field of the side which has sandwiched the liquid crystal molecular layer of each transparence substrate is characterized by being the configuration which makes thickness distribution of this liquid crystal molecular layer the similarity configuration over phase distribution of the spherical aberration which produces a signal recording surface according to the thickness error of a wrap clear layer in an optical record medium.
[0014] In the optical pickup concerning this invention moreover, a liquid crystal device The field of the side which put the liquid crystal molecular layer, was constituted by the transparence substrate of a pair, and has sandwiched the above-mentioned liquid crystal molecular layer of each transparence substrate It is characterized by being the configuration which makes a different selected signal recording surface according to selection of a signal recording surface [in / for thickness distribution of this liquid crystal molecular layer / a multilayer optical record medium] the similarity configuration over phase distribution of the spherical aberration according to the thickness of a wrap clear layer.
[0015] Furthermore, in the optical pickup concerning this invention, a liquid crystal device puts a liquid crystal molecular layer, is constituted by the transparence substrate of a pair, and is characterized by the field of the side which has sandwiched the above-mentioned liquid crystal molecular layer of each transparence substrate serving as a configuration which makes thickness distribution of this liquid crystal molecular layer the similarity configuration over phase distribution of the comatic aberration produced with the inclination to the optical axis of the objective lens of an optical record medium.
[0016] In the optical pickup concerning such this invention, it is continued and formed in the whole surface at the transparence substrate of the pair which puts a liquid crystal molecular layer, without dividing an electrode. And a uniform electrical potential difference is impressed to this electrode. That is, phase distribution of the transmitted light is decided by thickness of the liquid crystal molecule to penetrate.
[0017] Thus, in the optical pickup concerning this invention, since the electrode in a liquid crystal device is not divided, loss of the amount of transmitted lights by diffraction etc. is not invited.
[0018] Moreover, since phase distribution of the transmitted light of this liquid crystal device is decided by the optical path length who penetrates a liquid crystal device, it is decided by thickness distribution of liquid crystal. Since thickness distribution of liquid crystal is decided by the configuration of a transparence substrate, if the similarity configuration over desired phase distribution can be formed in the front face of a transparence substrate, it will become possible

[giving phase distribution ideal for the transmitted light].
[0019]
[Embodiment of the Invention] It explains to a detail, referring to a drawing about the gestalt of concrete operation of this invention hereafter.
[0020] The optical pickup concerning this invention is equipped with the liquid crystal device 3 arranged into the optical path between the objective lens 2 which condenses to signal recording surface 101a of the optical disk 101 which is an optical record medium, and irradiates at it the semiconductor laser 1 used as the light source, and the flux of light emitted from this semiconductor laser 1, and these semiconductor laser 1 and an objective lens 2 as shown in drawing 1 .
[0021] The laminating of a base material 102 and the protective layer 103 is carried out, an optical disk 101 is constituted, and the field which is a front face of a base material 102 and was covered with the protective layer 103 has become signal recording surface 101a. The flux of light from an optical pickup penetrates a protective layer 103, and is irradiated by signal recording surface 101a. A front **** front face is a flat surface, and a liquid crystal device 3 gives predetermined phase distribution to the transmitted light so that it may mention later.
[0022] In this optical pickup, the flux of light which is the linearly polarized light emitted from semiconductor laser 1 is collimated by the collimator lens 4, and serves as a plane wave. Incidence of this plane wave is carried out to a beam splitter 5. This plane wave serves as P polarization to reflector 5a of a beam splitter 5, penetrates this reflector 5a, and penetrates a liquid crystal device 3. And this plane wave is made with the circular polarization of light through the quarter wavelength (lambda/4) plate 6, and results in an objective lens 2. This objective lens 2 condenses and irradiates the flux of light by which incidence was carried out at signal recording surface 101a of an optical disk 101.
[0023] the direction of tracking (direction which intersects perpendicularly with the optical axis of an objective lens 2) which shows an objective lens 2 by the direction of a focus (the direction of an optical axis of an objective lens 2) shown by the drawing 1 Nakaya mark F with the biaxial actuator 7, and the drawing 1 Nakaya mark T -- migration -- it is supported operational. Focusing adjustment and tracking adjustment are performed by actuation of this biaxial actuator 7.
[0024] And it is reflected by this signal recording surface 101a, and the flux of light condensed by signal recording surface 101a of an optical disk 101 serves as outward trip light and the circular polarization of light of an opposite direction, serves as the linearly polarized light of the direction which intersects perpendicularly in the polarization direction of outward trip light through an objective lens 2 and the quarter wavelength (lambda/4) plate 6, penetrates a liquid crystal device 3, and returns to a beam splitter 5. In this beam splitter 5, since the light which returned from the optical disk 101 is S polarization to reflector 5a of this beam splitter 5, it is reflected by this reflector 5a. It converges with the detection lens 8 and the flux of light reflected in the beam splitter 5 is received by the photodetector 10 through the multi-lens 9. The multi-lens 9 is a lens with which plane of incidence was made with the cylinder side, and the outgoing radiation side was made with the concave surface.
[0025] In this optical pickup, a liquid crystal device 3 gives predetermined phase distribution which erases the aberration produced in signal recording surface 101a about the flux of light irradiated by signal recording surface 101a inside to transmitted light flux.
[0026] That is, the phase distribution which a liquid crystal device 3 should give to the transmitted light turns into the phase distribution of wave aberration and the distribution of reversed polarity in the optical spot by which image formation was carried out on signal recording surface 101a with the objective lens 2.
[0027] For example, aberration to amend considers the case where it is what is depended on the thickness error dt and Skew theta of a protective layer 103 of an optical disk 101. Spherical aberration and Skew theta generate [error / dt / thickness] comatic aberration. Each aberration of a low degree is given by the degree type about aberration, and effect becomes large, so that the numerical aperture (NA) of an objective lens 2 is large and the wavelength of the flux of light emitted from semiconductor laser 1 is short.

[0028] That is, the 3rd spherical-aberration multiplier is given by the degree type.
[0029]
W40=dt/8x(n2-1)/n3xNA4 and the 3rd comatic-aberration multiplier are given by the degree type.
[0030] W31=t/2x(n2-1) xn2xsin thetaxcos theta/(n2-sin2theta)5/2xNA3 (**t: thickness of the protective layer of an optical disk)
(**dt: Thickness error of the protective layer of an optical disk)
(**n: ****** of the protective layer of an optical disk)
(**theta: Inclination of an optical disk)
A degree type will be obtained if such aberration is expressed with the coordinate (x y) standardized in the pupil radius on the pupil surface of an objective lens 2.
[0031]
3rd spherical aberration w(x y) =w40(x2+y2) 2 .... (formula 1)
3rd comatic aberration w(x y) =w31x (x2+y2) .... (formula 2)
Numerical aperture (NA) of an objective lens 2 cannot express the phase distribution corresponding to aberration sufficiently correctly only by the aberration of a low degree, when large. High order aberration is given by the degree type.
[0032] That is, the 5th spherical-aberration multiplier is given by the degree type.
[0033] W60=dt/48x(n2-1) x(n2+3)/n5xNA6 and the 5th comatic-aberration multiplier are given by the degree type.
[0034] W51=t/8x(n2-1) xn2xsinthetaxcostheta/(n2-sin2theta) 9/2xNA5x (n4+(3cos2theta-5sin2theta) n2+4sin2theta-sin4theta)
A degree type will be obtained if such aberration is expressed with the coordinate (x y) standardized in the pupil radius on the pupil surface of an objective lens 2.
[0035]
5th spherical aberration w(x y) =w60(x2+y2) 3 .... (formula 3)
5th comatic aberration w(x y) =w51x(x2+y2)2 .... (formula 4)
However, since the effect which gives high order aberration practically near the spot center of the light condensed with the objective lens 2 is very small, there is also little effect which it has on record playback of an optical disk. Therefore, the aberration which should be amended is enough if only the aberration of a low degree is taken into consideration.
[0036] And as shown in drawing 2 and drawing 3 , a liquid crystal device 3 puts the liquid crystal molecular layer 13, and consists of two glass substrates 11 and 12 which are transparence substrates of a pair. Plane of incidence, an outgoing radiation side, i.e., a front face, and a rear face are made with a flat surface, and this liquid crystal device 3 is constituted. And in this liquid crystal device 3, thickness distribution of the liquid crystal layer 13 is made with the similarity configuration over phase distribution to give to the transmitted light of this liquid crystal device 3. Namely, one side is made with a flat surface and, as for the fields 11a and 12a whose liquid crystal layers 13 each glass substrates 11 and 12 countered mutually, and are pinched, another side is made with the similarity configuration over desired phase distribution.
[0037] In this liquid crystal device 3, as shown in drawing 4 and drawing 5 , it continues all over the fields 11a and 12a where each glass substrates 11 and 12 counter mutually, and one electrodes 14 and 15 are formed, respectively. Furthermore, the orientation film 16 and 17 is formed on these electrodes 14 and 15. The liquid crystal molecule of the liquid crystal layer 13 is located in a line along with the orientation film 16 and 17. As shown in drawing 4 , in the electrode 14 and the condition that the electrical potential difference is not impressed among 15, orientation of these liquid crystal molecule is carried out considering the direction of a major axis as parallel to the fields 11a and 12a of glass substrates 11 and 12. And these liquid crystal molecule will move to the condition of making the direction of a major axis perpendicular to the fields 11a and 12a of glass substrates 11 and 12, if an electrical potential difference is impressed between an electrode 14 and 15 as shown in drawing 5 . The refractive indexes of the liquid crystal layer 13 differ by the case where the polarization direction of incident light is in agreement in the direction of a major axis of a liquid crystal molecule, and the case where the polarization direction of incident light is not in agreement in the direction of a major axis of a

liquid crystal molecule. Here, the direction of a major axis of a liquid crystal molecule is parallel to the fields 11a and 12a of glass substrates 11 and 12, and the refractive index of the liquid crystal layer 13 when the polarization direction of incident light is in agreement in the direction of a major axis of a liquid crystal molecule is set to n1. Moreover, the refractive index of the liquid crystal layer 13 when the direction of a major axis of a liquid crystal molecule is perpendicular to the fields 11a and 12a of glass substrates 11 and 12 is set to n2. And in the condition that the direction of a major axis of a liquid crystal molecule is slanting to the fields 11a and 12a of glass substrates 11 and 12, the refractive index of the liquid crystal layer 13 serves as a value between n1 and n2 according to the include angle of a liquid crystal molecule.
[0038] When there is no need of giving phase distribution to the transmitted light of a liquid crystal device 3, namely, when there is no manufacture error in this optical pickup and optical disk 101 and it is non-aberration in respect of image formation, the electrode 14 of a liquid crystal device 3 and the electrical potential difference impressed among 15 are adjusted, and it is made for the refractive index of the liquid crystal layer 13 to become equal to the refractive index n3 of each glass substrates 11 and 12 in this optical pickup, as shown in drawing 6 .
[0039] And as shown in drawing 7 , ****** of the liquid crystal layer 13 is changed by changing an electrode 14 and the electrical potential difference impressed among 15 to give phase distribution to the transmitted light of a liquid crystal device 3.
[0040] Phase distribution of the transmitted light of a liquid crystal device 3 is decided by the optical path length in a liquid crystal device 3. That is, phase distribution of the transmitted light of a liquid crystal device 3 is decided by the product (d (x) -deltan) of thickness distribution [of the liquid crystal layer 13] d (x), and ******** deltan between the liquid crystal layer 13 and each glass substrate 11, and 12. Therefore, similar phase distribution can be given to the transmitted light of a liquid crystal device 3 to thickness distribution of the liquid crystal layer 13 by changing an electrode 14 and the electrical potential difference impressed among 15, and producing ******** deltan between the liquid crystal layer 13 and each glass substrate 11, and 12.
[0041] A wave front when having produced spherical aberration turns into a wave front which phase contrast has produced in the center section and periphery of the flux of light, as shown in drawing 8 . Moreover, a wave front when having produced comatic aberration turns into a wave front which phase contrast is producing gradually in the 1 side [flux of light] and side side else, as shown in drawing 9 . Therefore, it becomes non-aberration, when giving these phase distribution and phase distribution of reversed polarity beforehand to the wave front of the transmitted light of a liquid crystal device 3 and image formation is carried out with an objective lens 2.
[0042] Therefore, in order to amend spherical aberration, thickness distribution of the liquid crystal layer 13 in a liquid crystal device 3 is made into the configuration shown with the above (formula 1) as shown in drawing 10 . Moreover, in order to amend comatic aberration, thickness distribution of the liquid crystal layer 13 in a liquid crystal device 3 is made into the configuration shown with the above (formula 2) as shown in drawing 11 .
[0043] And you may arrange in piles in the optical path which faces each to an objective lens 2 as the liquid crystal device for amending the liquid crystal device and comatic aberration for amending such spherical aberration as shown in drawing 1 , or only either may be arranged. The sequence piled up when arranging in piles the liquid crystal device which amends spherical aberration, and the liquid crystal device which amends comatic aberration may be any, and may pile any up as a side near an objective lens 2.
[0044] In addition, in this optical pickup, even if thickness distribution of the liquid crystal layer 13 in a liquid crystal device 3 is not the configuration of similarity in phase distribution of spherical aberration or comatic aberration, amendment of aberration is possible. For example, since focus servo actuation according to the 2 shaft actuator 7 also as a configuration corresponding to the phase distribution to which the aberration by defocusing was added to spherical aberration amends a defocused part, amendment of aberration can be performed. However, since what is necessary is just to give phase distribution of reversed polarity about the phase distribution and the amplitude by the aberration itself in order for there to be no

semantics in making it such a configuration not much and to attain amendment of aberration by the minimum phase correction, the configuration shown in the above drawing 10 and drawing 11 is the optimal.
[0045] Moreover, this invention is effective also in the optical pickup used to the so-called multilayer disk. In a multilayer disk, since the transparent protective layer intervenes between each side of two or more signal recording surfaces by which the laminating was carried out, for every signal recording surface, the thickness from the front face of an optical disk differs, and the spherical aberration to generate differs.
[0046] For example, in the case of "DVD (trademark)", the two-layer disk is adopted, spherical aberration sets up two-layer spacing as range permitted, and the optical pickup is designed, and does not have especially the amendment device of spherical aberration.
[0047] However, when you want to increase a signal recording surface further from two-layer in "DVD (trademark)", or when numerical aperture (NA) of an objective lens is enlarged even if it is two-layer, nonpermissible big spherical aberration occurs.
[0048] In order to reduce spherical aberration, it can think that what is necessary is to be thin in between layers, namely, just to make signal recording surfaces approach, but when between layers is made thin, while performing record and playback about a certain signal recording surface, the stray light from other signal recording surfaces returns to an optical pickup, and exact record and playback become here, impossible. Therefore, there is a limitation in making between layers thin. This limitation changes with designs of a system, luminescence wavelength of the light source, etc. including optical system. However, when the lower limit of the interlayer spacing from which the stray light from other signal recording surfaces does not pose a problem has exceeded the upper limit of the interlayer spacing which can permit spherical aberration, it is necessary to amend spherical aberration efficiently with a certain means.
[0049] Then, if it is going to amend spherical aberration using the conventional liquid crystal device which has the divided electrode, since only approximation-amendment can be performed, residual aberration is large and big spherical aberration [as / in a multilayer disk] cannot be amended. Moreover, by generating a spherical wave and making it put to an objective lens ON, only approximation-amendment can be performed, and since residual aberration is large, big spherical aberration in a multilayer disk cannot be amended.
[0050] Since amendment of the spherical aberration in this invention amends the change of the configuration of the wave front by spherical aberration itself to it, when amending the big spherical aberration generated when using a multilayer disk, little good amendment of residual aberration can be performed.
[0051] In addition, in the gestalt of operation mentioned above, although considered as the configuration of similarity in phase distribution of a request of one configuration of the fields of the glass substrate whose liquid crystal layer is pinched in the liquid crystal device, this invention is good for phase distribution of a request of the configuration of both sides of the field of the glass substrate not only this but whose liquid crystal layer is pinched also as a similar configuration.
[0052] Namely, since phase distribution to give the transmitted light of a liquid crystal device is decided by the product (d (x) -deltan) of thickness distribution [of the liquid crystal layer put with the glass substrate] d (x), and a liquid crystal layer and ******** deltan between each glass substrate, it does not depend on the configuration of a glass substrate, but thickness distribution of a liquid crystal layer has just become an analog to desired phase distribution.
[0053] Moreover, the field configuration of the field which puts the liquid crystal layer of each glass substrate may form a predetermined field configuration for example, with an ultraviolet-rays (UV) curing agent, and may form it by sticking this on a plane glass substrate.
[0054]

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the side elevation in which fracturing a part and showing the configuration of the optical pickup concerning this invention.
[Drawing 2] It is drawing of longitudinal section showing the configuration of the liquid crystal device which performs aberration amendment in the above-mentioned optical pickup.
[Drawing 3] It is the front view showing the configuration of the above-mentioned liquid crystal device.
[Drawing 4] It is drawing of longitudinal section showing the configuration of the important section in the condition of not impressing the electrical potential difference of the above-mentioned liquid crystal device.
[Drawing 5] It is drawing of longitudinal section showing the configuration of the important section in the condition of impressing the electrical potential difference of the above-mentioned liquid crystal device.
[Drawing 6] It is drawing of longitudinal section showing the configuration of the important section in the condition of having adjusted applied voltage in the above-mentioned liquid crystal device, and having made the refractive index of a liquid crystal layer equal to the refractive index of a glass substrate.
[Drawing 7] It is drawing of longitudinal section showing the configuration of the important section in the condition of having changed applied voltage in the above-mentioned liquid crystal device, and having changed the refractive index of a liquid crystal layer with the refractive index of a glass substrate.
[Drawing 8] It is the graph which shows the wave front generated according to spherical aberration.
[Drawing 9] It is the graph which shows the wave front generated according to comatic aberration.
[Drawing 10] It is drawing of longitudinal section showing the configuration of the important section of the liquid crystal device for amending spherical aberration.
[Drawing 11] It is drawing of longitudinal section showing the configuration of the important section of the liquid crystal device for amending comatic aberration.
[Description of Notations]
1 Semiconductor Laser, 2 Objective Lens, 3 11 Liquid Crystal Device, 12 Glass Substrate, 13 14 Liquid Crystal Layer, 15 Electrode

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[Translation done.]

* NOTICES *

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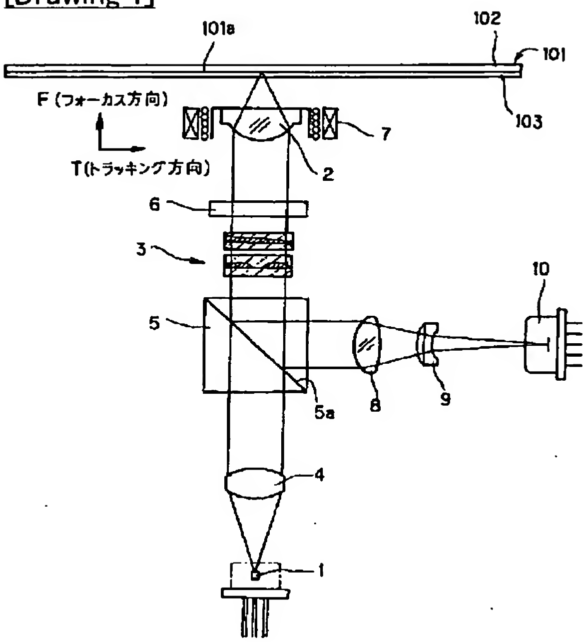
damages caused by the use of this translation.

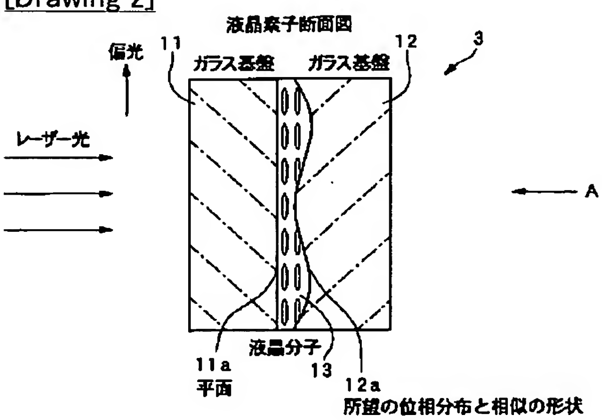
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

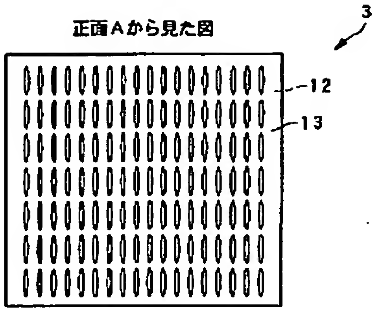
[Drawing 1]



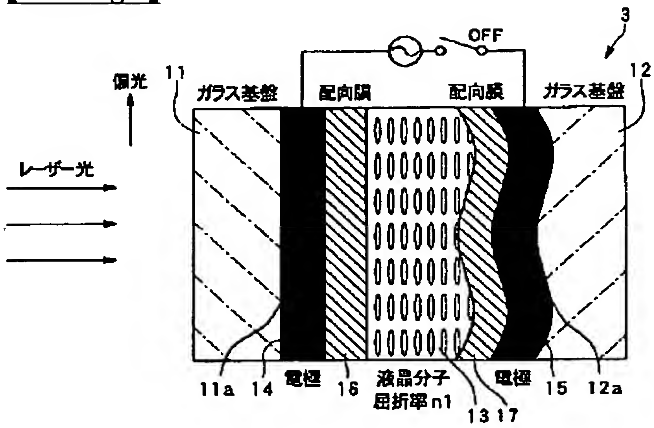
[Drawing 2]



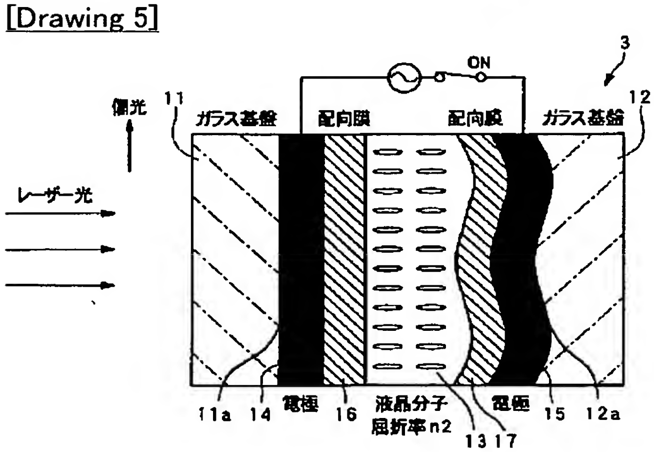
[Drawing 3]



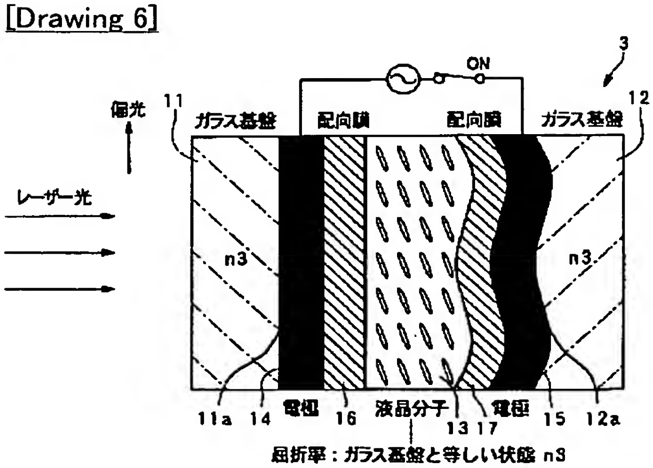
[Drawing 4]



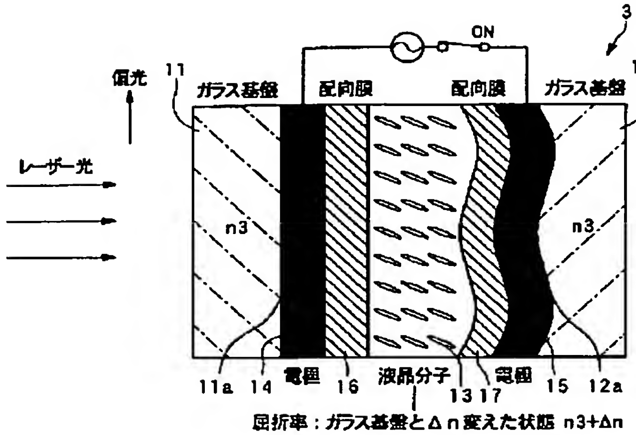
[Drawing 5]



[Drawing 6]

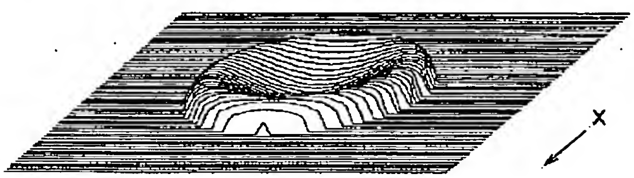


[Drawing 7]



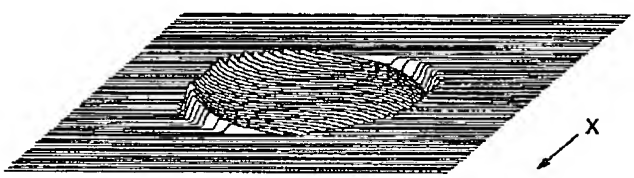
[Drawing 8]

球面収差

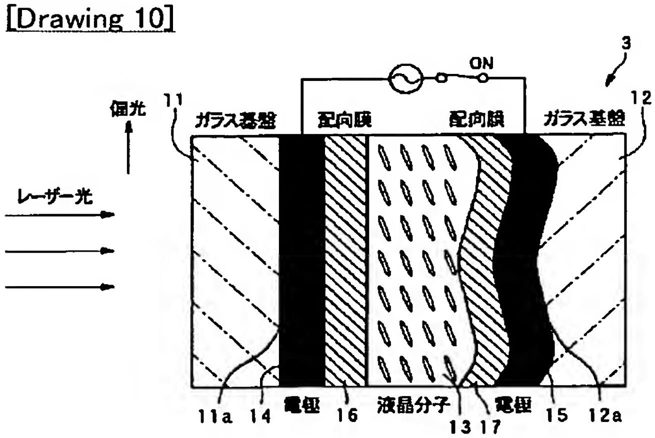


[Drawing 9]

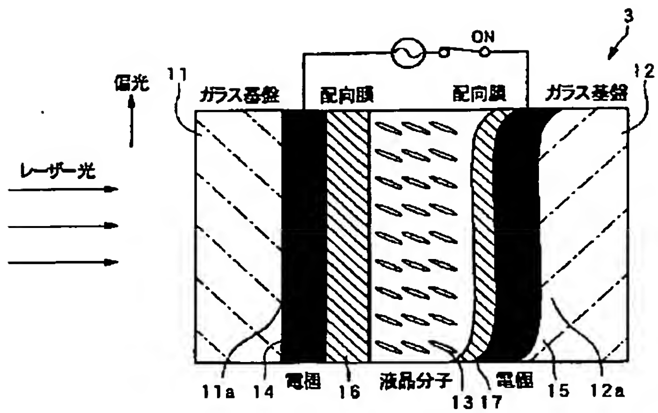
コマ収差



[Drawing 10]



[Drawing 11]



[Translation done.]

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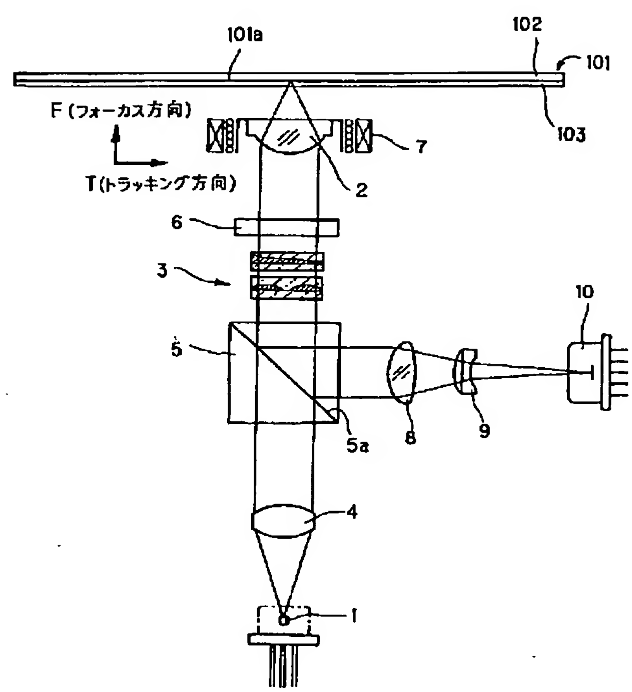
(54)【発明の名称】　光学ピックアップ装置

(57)【要約】
【課題】　光源から発せられる光の損失を極力抑えつつ、光学素子の種々の製造誤差により発生する波面収差を良好に補正し、特に光学記録媒体の厚み誤差や傾き誤差などによる収差をも良好に補正する。
【解決手段】　光源１と、この光源１から発せられた光束を光学記録媒体１０１の信号記録面１０１ａに集光して照射する対物レンズ２と、これら光源１及び対物レンズ２間の光路中に配設され表裏両表面が平面であって透過光に対し所定の位相分布を与える液晶素子３とを備え、この液晶素子３は、一対の透明基板によって液晶分子層を挟み込んで構成され、各透明基板の液晶分子層を挟んでいる側の面は、この液晶分子層の厚み分布を所定の収差による位相分布に対する相似形状とする形状となっている。



【特許請求の範囲】

【請求項１】　光源と、この光源から発せられた光束を光学記録媒体の信号記録面に集光して照射する対物レンズと、これら光源及び対物レンズ間の光路中に配設され表裏両表面が平面であって透過光に対し所定の位相分布を与える液晶素子とを備える光学ピックアップ装置であって、
上記液晶素子は、一対の透明基板によって液晶分子層を挟み込んで構成され、
上記各透明基板の上記液晶分子層を挟んでいる側の面は、該液晶分子層の厚み分布を、光学記録媒体において信号記録面を覆う透明層の厚み誤差により生じる球面収差の位相分布に対する相似形状とする形状となっていることを特徴とする光学ピックアップ装置。

【請求項２】　各透明基板の液晶分子層を挟んでいる側の面のうちの一方は、平面であることを特徴とする請求項１記載の光学ピックアップ装置。

【請求項３】　光源と、この光源から発せられた光束を多層光学記録媒体の複数の信号記録面のうちの一に選択的に集光して照射する対物レンズと、これら光源及び対物レンズ間の光路中に配設され表裏両表面が平面であって透過光に対し所定の位相分布を与える液晶素子とを備える光学ピックアップ装置であって、
上記液晶素子は、一対の透明基板によって液晶分子層を挟み込んで構成され、
上記各透明基板の上記液晶分子層を挟んでいる側の面は、該液晶分子層の厚み分布を、多層光学記録媒体における信号記録面の選択に応じて異なる選択された信号記録面を覆う透明層の厚さに応じた球面収差の位相分布に対する相似形状とする形状となっていることを特徴とする光学ピックアップ装置。

【請求項４】　各透明基板の液晶分子層を挟んでいる側の面のうちの一方は、平面であることを特徴とする請求項３記載の光学ピックアップ装置。

【請求項５】　光源と、この光源から発せられた光束を光学記録媒体の信号記録面に集光して照射する対物レンズと、これら光源及び対物レンズ間の光路中に配設され表裏両表面が平面であって透過光に対し所定の位相分布を与える液晶素子とを備える光学ピックアップ装置であって、
上記液晶素子は、一対の透明基板によって液晶分子層を挟み込んで構成され、
上記各透明基板の上記液晶分子層を挟んでいる側の面は、該液晶分子層の厚み分布を光学記録媒体の対物レンズの光軸に対する傾きにより生じるコマ収差の位相分布に対する相似形状とする形状となっていることを特徴とする光学ピックアップ装置。

【請求項６】　各透明基板の液晶分子層を挟んでいる側の面のうちの一方は、平面であることを特徴とする請求項５記載の光学ピックアップ装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、いわゆる光ディスクシステム、光磁気ディスクシステム、光カードシステム等の光学式記録再生装置を構成する光学ピックアップ装置に関する。

【０００２】

【従来の技術】従来、光学記録媒体として、例えば「ＣＤ（Compact Disc）（商標）」や「ＤＶＤ（Digital Versatile Disc）（商標）」の如き光ディスクが提案され、このような光ディスクに対して情報信号の書込みまたは読出しを行う光学ピックアップ装置が提案されている。

【０００３】そして、近年、このような光ディスクにおける記録容量の増大を図るために、光学ピックアップ装置において光源から発せられる光束の短波長化及びこの光束を光ディスクの信号記録面上に集光させる対物レンズの高ＮＡ（開口数）化が行われている。

【０００４】例えば、光学ピックアップ装置における光源となる半導体レーザ（ＬＤ）の発光波長としては、「ＣＤ（商標）」用の光学ピックアップ装置においては７８０ｎｍであるが、より記録容量の大きな「ＤＶＤ（商標）」用の光学ピックアップ装置においては６５０ｎｍである。また、光学ピックアップ装置の対物レンズの開口数（ＮＡ）としては、「ＣＤ（商標）」用の光学ピックアップ装置においては０．４５であるが、「ＤＶＤ（商標）」用の光学ピックアップ装置においては０．６０である。

【０００５】さらに、発光波長が４０５ｎｍ（青紫色）の半導体レーザや、開口数（ＮＡ）が０．８５の対物レンズも提案されており、これらを光学ピックアップ装置に使用することにより、光ディスクの記録容量のさらなる増大が図られることとなる。

【０００６】

【発明が解決しようとする課題】ところで、上述のように、光源となる半導体レーザの発光波長を短波長化し、対物レンズの高ＮＡ化を図ると、種々の製造誤差による光学系における波面収差の増大に対する影響が大きくなる。すなわち、製造誤差が同程度であった場合、半導体レーザの発光波長を短波長化するほど、また、対物レンズが高ＮＡ化するほど、波面収差は増大する。光学系における波面収差が増大すると、光学性能が劣化し、情報信号の良好な書込み及び読出しが行えなくなる。

【０００７】そのため、例えば、従来の「ＤＶＤ（商標）」用の光学ピックアップ装置においては、光ディスクにスキューが生じた場合にこの光ディスクの読取り面に対して常に光軸を垂直とするように、光学ピックアップ装置と光ディスクとの相対的な傾きを変化させる機構を備えたものが提案されている。

【０００８】しかしながら、このように、光学ピックア

ップ装置全体の光ディスクに対する傾きを調整するのみでは、光学素子の種々の製造誤差により発生する種々の波面収差を良好に補正することはできず、特に、光学記録媒体の厚み誤差や傾き誤差などによる波面収差を良好に補正することはできない。

【０００９】そして、光学ピックアップ装置における波面収差を補正するための構成としては、従来、他にもさまざまなものが提案されている。その一つに、液晶素子を用いたものがある。これは、光源と対物レンズとの間の光路上に液晶素子を挿入しておき、この液晶素子によって、透過光に対して所望の位相分布を与えるという構成である。すなわち、この構成は、発生する波面収差と逆の位相を液晶素子により入射光にあらかじめ与え、結像面において無収差にするというものである。

【００１０】液晶素子において、液晶分子を挟み込む基板は、通常、ガラスの平面基板からなる。この基板には、液晶に電圧を加えるための電極が形成されている。液晶分子は、ガラス基板に形成された配向膜に沿って並んでおり、基板に形成された電極により印加される電圧により動かされる。このような液晶分子の移動に伴って、液晶素子全体の屈折率がかわるので、この液晶素子の透過光の位相を変えることが可能である。そして、透過光に位相分布を与えるには、電極により印加する電圧に電圧分布を作ればよい。そのための簡単な構成としては、電極を少なくとも２つ以上に分割して形成することが挙げられる。これら分割された電極に、所望の位相分布に対応した電圧を個々別々に加えることによって、電極数と印加電圧に見合った電圧分布が形成され、近似的に所望の位相分布の透過光に得ることができる。もちろん、電極の分割数を多くして細かく分割するほど、理想的な位相分布を発生させることができる。

【００１１】しかし、このような液晶素子において、電極の分割数を多くすればするほど、電極同士の間に形成される無電極部の面積が大きくなる。そして、無電極部の液晶は、電極部の液晶に対して屈折率が異なるので、結像に悪影響を与えるのみならず、電極部の液晶との境界で光の回折などの現象を生じさせ、光量の損失の原因となる。光源となる半導体レーザのパワーに余裕があれば、このような回折光による光量損失は問題とならないが、半導体レーザの寿命を伸ばすためには、液晶素子における光量の損失は少ないほうがよい。

【００１２】そこで、本発明は、上述の実情に鑑みて提案されたものであって、光源から発せられる光の損失を極力抑えつつ、光学素子の種々の製造誤差により発生する波面収差を良好に補正することができ、特に光学記録媒体の厚み誤差や傾き誤差などによる収差をも良好に補正することができる光学ピックアップ装置を提供しようとするものである。

【００１３】

【課題を解決するための手段】上述の課題を解決するため、本発明に係る光学ピックアップ装置は、光源と、この光源から発せられた光束を光学記録媒体の信号記録面に集光して照射する対物レンズと、これら光源及び対物レンズ間の光路中に配設され表裏両表面が平面であって透過光に対し所定の位相分布を与える液晶素子とを備える光学ピックアップ装置である。そして、液晶素子は、一対の透明基板によって液晶分子層を挟み込んで構成され、各透明基板の液晶分子層を挟んでいる側の面は、この液晶分子層の厚み分布を光学記録媒体において信号記録面を覆う透明層の厚み誤差により生じる球面収差の位相分布に対する相似形状とする形状となっていることを特徴とするものである。

【００１４】また、本発明に係る光学ピックアップ装置において、液晶素子は、一対の透明基板によって液晶分子層を挟み込んで構成され、各透明基板の上記液晶分子層を挟んでいる側の面は、この液晶分子層の厚み分布を多層光学記録媒体における信号記録面の選択に応じて異なる選択された信号記録面を覆う透明層の厚さに応じた球面収差の位相分布に対する相似形状とする形状となっていることを特徴とするものである。

【００１５】さらに、本発明に係る光学ピックアップ装置において、液晶素子は、一対の透明基板によって液晶分子層を挟み込んで構成され、各透明基板の上記液晶分子層を挟んでいる側の面は、この液晶分子層の厚み分布を光学記録媒体の対物レンズの光軸に対する傾きにより生じるコマ収差の位相分布に対する相似形状とする形状となっていることを特徴とするものである。

【００１６】このような本発明に係る光学ピックアップ装置においては、液晶分子層を挟み込む一対の透明基板には、電極が分割されることなく全面に亘って形成される。そして、この電極には、一様の電圧が印加される。すなわち、透過光の位相分布は、透過する液晶分子の厚みで決まる。

【００１７】このように、本発明に係る光学ピックアップ装置においては、液晶素子における電極が分割されていないので、回折などによる透過光量の損失が招来されない。

【００１８】また、この液晶素子の透過光の位相分布は、液晶素子を透過する光路長で決まるので、液晶の厚み分布できまる。液晶の厚み分布は、透明基板の形状で決まるので、所望の位相分布に対する相似形状を透明基板の表面に形成することができれば、透過光に理想的な位相分布を与えることが可能となる。

【００１９】

【発明の実施の形態】以下、本発明の具体的な実施の形態について図面を参照しながら詳細に説明する。

【００２０】本発明に係る光学ピックアップ装置は、図１に示すように、光源となる半導体レーザ１と、この半導体レーザ１から発せられた光束を光学記録媒体である光ディスク１０１の信号記録面１０１ａに集光して照射

する対物レンズ２と、これら半導体レーザ１及び対物レンズ２間の光路中に配設された液晶素子３とを備えている。

【００２１】光ディスク１０１は、基材１０２及び保護層１０３が積層されて構成され、基材１０２の表面であって保護層１０３に覆われた面が信号記録面１０１ａとなっている。光学ピックアップ装置からの光束は、保護層１０３を透過して、信号記録面１０１ａに照射される。液晶素子３は、表裏両表面が平面であって、後述するように、透過光に対し所定の位相分布を与えるものである。

【００２２】この光学ピックアップ装置において、半導体レーザ１から発せられた直線偏光である光束は、コリメータレンズ４によってコリメートされ、平面波となる。この平面波は、ビームスプリッタ５に入射する。この平面波は、ビームスプリッタ５の反射面５ａに対してＰ偏光となっており、この反射面５ａを透過し、液晶素子３を透過する。そして、この平面波は、四分の一波長（λ／４）板６を経て円偏光となされ、対物レンズ２に至る。この対物レンズ２は、入射された光束を、光ディスク１０１の信号記録面１０１ａに集光して照射する。

【００２３】対物レンズ２は、２軸アクチュエータ７によって、図１中矢印Ｆで示すフォーカス方向（対物レンズ２の光軸方向）及び図１中矢印Ｔで示すトラッキング方向（対物レンズ２の光軸に直交する方向）に移動操作可能に支持されている。この２軸アクチュエータ７の動作により、フォーカシング調整及びトラッキング調整が行われる。

【００２４】そして、光ディスク１０１の信号記録面１０１ａに集光された光束は、この信号記録面１０１ａにより反射され、往路光と反対方向の円偏光となって、対物レンズ２及び四分の一波長（λ／４）板６を経て、往路光の偏光方向に直交する方向の直線偏光となり、液晶素子３を透過し、ビームスプリッタ５に戻る。光ディスク１０１より戻った光は、このビームスプリッタ５においては、このビームスプリッタ５の反射面５ａに対してＳ偏光となっているためにこの反射面５ａにより反射される。ビームスプリッタ５において反射された光束は、検出レンズ８によって収束され、マルチレンズ９を経て、光検出器１０によって受光される。マルチレンズ９は、入射面が円筒面となされ、出射面が凹面となされたレンズである。

【００２５】この光学ピックアップ装置において、液晶素子３は、信号記録面１０１ａに照射される光束について信号記録面１０１ａにおいて生ずる収差をうち消すような所定の位相分布を透過光束に与えるものである。

【００２６】すなわち、液晶素子３が透過光に対して与えるべき位相分布は、対物レンズ２により信号記録面１０１ａ上に結像された光スポットにおける波面収差の位相分布と逆極性の分布となる。

【００２７】例えば、補正したい収差が、光ディスク１０１の保護層１０３の厚み誤差ｄｔとスキューθによるものである場合を考える。厚み誤差ｄｔは球面収差、スキューθはコマ収差を発生させる。それぞれの低次の収差は、収差に関する次式で与えられ、対物レンズ２の開口数（ＮＡ）が大きく、半導体レーザ１から発せられる光束の波長が短いほど、影響は大きくなる。

【００２８】すなわち、３次の球面収差係数は、次式で与えられる。

【００２９】

$W_{40} = dt/8 \times (n^2-1)/n^3 \times NA^4$

また、３次のコマ収差係数は、次式で与えられる。

【００３０】$W_{31} = t/2 \times (n^2-1) \times n^2 \times \sin\theta \times \cos\theta / (n^2 - \sin^2\theta)^{5/2} \times NA^3$

（∵ｔ：光ディスクの保護層の厚み）

（∵ｄｔ：光ディスクの保護層の厚み誤差）

（∵ｎ：光ディスクの保護層の屈折率）

（∵θ：光ディスクの傾き）

これらの収差を、対物レンズ２の瞳面上の瞳半径で規格化された座標（ｘ，ｙ）で表すと、次式が得られる。

【００３１】

３次の球面収差　$w(x, y) = w_{40}(x^2+y^2)^2$　・・・・（式１）

３次のコマ収差　$w(x, y) = w_{31}\,x(x^2+y^2)$　・・・・（式２）

対物レンズ２の開口数（ＮＡ）が大きい場合には、低次の収差のみでは、収差に対応した位相分布を十分正確に表現することができない。高次の収差は、次式で与えられる。

【００３２】すなわち、５次の球面収差係数は、次式で与えられる。

【００３３】$W_{60} = dt/48 \times (n^2-1) \times (n^2+3)/n^5 \times NA^6$

また、５次のコマ収差係数は、次式で与えられる。

【００３４】$W_{51} = t/8 \times (n^2-1) \times n^2 \times \sin\theta \times \cos\theta / (n^2 - \sin^2\theta)^{9/2} \times NA^5 \times (n^4 + (3\cos^2\theta - 5\sin^2\theta)n^2 + 4\sin^2\theta - \sin^4\theta)$

これらの収差を対物レンズ２の瞳面上の瞳半径で規格化された座標（ｘ，ｙ）で表すと、次式が得られる。

【００３５】

５次の球面収差　$w(x, y) = w_{60}(x^2+y^2)^3$　・・・・（式３）

５次のコマ収差　$w(x, y) = w_{51}\,x(x^2+y^2)^2$　・・・・（式４）

しかしながら、実用上は、高次収差は、対物レンズ２により集光された光のスポットセンタの近傍に与える影響は微少であるため、光ディスクの記録再生に与える影響も少ない。したがって、補正すべき収差は、低次の収差

のみを考慮すれば十分である。

【００３６】そして、液晶素子３は、図２及び図３に示すように、一対の透明基板である２枚のガラス基板１１，１２で液晶分子層１３を挟み込んで構成されている。この液晶素子３は、入射面及び出射面、すなわち、表面及び裏面が平面となされて構成されている。そして、この液晶素子３において、液晶層１３の厚み分布は、この液晶素子３の透過光に対して与えたい位相分布に対する相似形状となされている。すなわち、各ガラス基板１１，１２の互いに対向して液晶層１３を挟んでいる面１１ａ，１２ａは、一方が平面となされ、他方が所望の位相分布に対する相似形状となされている。

【００３７】この液晶素子３においては、図４及び図５に示すように、各ガラス基板１１，１２の互いに対向する面１１ａ，１２ａの全面に亘って、それぞれ１つの電極１４，１５が形成されている。さらに、これら電極１４，１５上には、配向膜１６，１７が形成されている。液晶層１３の液晶分子は、配向膜１６，１７に沿って並んでいる。これら液晶分子は、図４に示すように、電極１４，１５間に電圧が印加されていない状態においては、長軸方向をガラス基板１１，１２の面１１ａ，１２ａに平行として配向されている。そして、これら液晶分子は、図５に示すように、電極１４，１５間に電圧が印加されると、長軸方向をガラス基板１１，１２の面１１ａ，１２ａに対して垂直とする状態に移動する。液晶層１３の屈折率は、入射光の偏光方向が液晶分子の長軸方向に一致している場合と、入射光の偏光方向が液晶分子の長軸方向に一致していない場合とで異なる。ここで、液晶分子の長軸方向がガラス基板１１，１２の面１１ａ，１２ａに平行で入射光の偏光方向が液晶分子の長軸方向に一致している場合の液晶層１３の屈折率をｎ１とする。また、液晶分子の長軸方向がガラス基板１１，１２の面１１ａ，１２ａに垂直である場合の液晶層１３の屈折率をｎ２とする。そして、液晶分子の長軸方向がガラス基板１１，１２の面１１ａ，１２ａに対して斜めになっている状態では、液晶層１３の屈折率は、液晶分子の角度に応じて、ｎ１とｎ２との間の値となる。

【００３８】この光学ピックアップ装置においては、液晶素子３の透過光に対して位相分布を与える必要のない場合、すなわち、この光学ピックアップ装置及び光ディスク１０１に製造誤差が無く、結像面で無収差である場合は、図６に示すように、液晶素子３の電極１４，１５間に印加する電圧を調整して、液晶層１３の屈折率が各ガラス基板１１，１２の屈折率ｎ３に等しくなるようにしておく。

【００３９】そして、液晶素子３の透過光に対して位相分布を与えたい場合には、図７に示すように、電極１４，１５間に印加する電圧を変化させることにより、液晶層１３の屈折率を変化させる。

【００４０】液晶素子３の透過光の位相分布は、液晶素子３における光路長で決まる。すなわち、液晶素子３の透過光の位相分布は、液晶層１３の厚み分布ｄ（ｘ）と、液晶層１３及び各ガラス基板１１，１２間の屈折率差Δｎとの積（ｄ（ｘ）・Δｎ）で決まる。したがって、電極１４，１５間に印加する電圧を変化させて液晶層１３及び各ガラス基板１１，１２間に屈折率差Δｎを生じさせることにより、液晶素子３の透過光に、液晶層１３の厚み分布に対して相似の位相分布を与えることができる。

【００４１】球面収差を生じているときの波面は、図８に示すように、光束の中央部と周辺部とに位相差が生じている波面となる。また、コマ収差を生じているときの波面は、図９に示すように、光束の一側側と他側側とで徐々に位相差が生じている波面となる。したがって、液晶素子３の透過光の波面に対し、予めこれらの位相分布と逆極性の位相分布を与えておけば、対物レンズ２によって結像したときに、無収差となる。

【００４２】したがって、液晶素子３における液晶層１３の厚み分布は、球面収差を補正するためには、図１０に示すように、前記（式１）によって示される形状とする。また、液晶素子３における液晶層１３の厚み分布は、コマ収差を補正するためには、図１１に示すように、前記（式２）によって示される形状とする。

【００４３】そして、このような球面収差を補正するための液晶素子とコマ収差を補正するための液晶素子とは、図１に示すように、それぞれを対物レンズ２に向かう光路中に重ねて配置してもよく、または、いずれか一方のみを配置してもよい。球面収差を補正する液晶素子とコマ収差を補正する液晶素子とを重ねて配置する場合においては、重ねる順序はいずれであってもよく、いずれを対物レンズ２に近い側として重ねてもよい。

【００４４】なお、この光学ピックアップ装置において、液晶素子３における液晶層１３の厚み分布が、球面収差やコマ収差の位相分布に相似の形状でなくとも、収差の補正は可能である。例えば、球面収差にデフォーカスによる収差が加えられた位相分布に対応した形状としても、二軸アクチュエータ７によるフォーカスサーボ動作がデフォーカス分を補正するので、収差の補正ができる。しかし、そのような形状にすることにはあまり意味がなく、最小の位相補正によって収差の補正を達成するには、収差そのものによる位相分布と振幅について逆極性の位相分布を与えればよいので、上述のような、図１０及び図１１に示した形状が最適である。

【００４５】また、本発明は、いわゆる多層ディスクに対して用いる光学ピックアップ装置においても有効である。多層ディスクにおいては、複数の積層された信号記録面の各面間に透明な保護層が介在しているので、信号記録面ごとに、光ディスクの表面からの厚みが異なり、発生する球面収差が異なる。

【００４６】例えば「ＤＶＤ（商標）」の場合において

は、２層ディスクが採用されており、光学ピックアップ装置は、球面収差が許容される範囲として２層の間隔を設定して設計されており、特に球面収差の補正機構を有していない。

【００４７】ところが、「ＤＶＤ（商標）」において信号記録面を２層よりさらに増やしたい場合や、２層であっても対物レンズの開口数（ＮＡ）を大きくした場合には、許容できない大きな球面収差が発生する。

【００４８】ここで、球面収差を低減させるためには、層間を薄く、すなわち、信号記録面同士を接近させれば良いようにも思えるが、層間を薄くすると、ある信号記録面について記録、再生を行っているときに他の信号記録面からの迷光が光学ピックアップ装置に戻ってしまい、正確な記録、再生ができなくなる。したがって、層間を薄くすることには限界がある。この限界は、光学系を含むシステムの設計や光源の発光波長などによって異なる。しかし、他の信号記録面からの迷光が問題とならない層間隔の下限値が、球面収差が許容できる層間隔の上限値を上回っている場合には、なんらかの手段で球面収差を効率良く補正することが必要となる。

【００４９】そこで、分割された電極を有する従来の液晶素子を用いて球面収差を補正しようとすると、近似的な補正しかできないので、残留収差が大きく、多層ディスクにおけるような大きな球面収差の補正をすることができない。また、球面波を発生させて対物レンズに入射させることによっても、近似的な補正しかできず、残留収差が大きいため、多層ディスクにおける大きな球面収差の補正をすることはできない。

【００５０】それに対して、本発明における球面収差の補正は、球面収差による波面の形状の変化そのものを補正するので、多層ディスクを用いる場合に発生する大きな球面収差を補正する場合においても、残留収差の少ない良好な補正が行える。

【００５１】なお、上述した実施の形態においては、液晶素子において液晶層を挟んでいるガラス基板の面のうちの一方のみの形状を所望の位相分布に相似の形状としているが、本発明はこれに限らず、液晶層を挟んでいるガラス基板の面の両面の形状を所望の位相分布に相似の形状としてもよい。

【００５２】すなわち、液晶素子の透過光に与えたい位相分布は、ガラス基板により挟み込まれた液晶層の厚み分布ｄ（ｘ）と、液晶層及び各ガラス基板間の屈折率差Δｎとの積（ｄ（ｘ）・Δｎ）で決まるので、ガラス基板の形状に依らず、液晶層の厚み分布が所望の位相分布に対する相似形になっていればよいのである。

【００５３】また、各ガラス基板の液晶層を挟み込む面の面形状は、例えば、紫外線（ＵＶ）硬化剤によって所定の面形状を形成し、これを平面のガラス基板に貼付けることによって形成してもよい。

【００５４】

【発明の効果】上述のように、本発明に係る光学ピックアップ装置は、光源と、この光源から発せられた光束を光学記録媒体の信号記録面に集光して照射する対物レンズと、これら光源及び対物レンズ間の光路中に配設され表裏両表面が平面であって透過光に対し所定の位相分布を与える液晶素子とを備える光学ピックアップ装置であって、液晶素子は、一対の透明基板によって液晶分子層を挟み込んで構成され、各透明基板の液晶分子層を挟んでいる側の面は、この液晶分子層の厚み分布を所定の収差による位相分布に対する相似形状とする形状となっていることを特徴とする。

【００５５】そして、この光学ピックアップ装置においては、液晶分子層を挟み込む一対の透明基板には、電極が分割されることなく全面に亘って形成される。そして、この電極には、一様の電圧が印加される。すなわち、透過光の位相分布は、透過する液晶分子の厚みで決まる。

【００５６】このように、本発明に係る光学ピックアップ装置においては、液晶素子における電極が分割されていないので、回折などによる透過光量の損失が招来されない。

【００５７】また、この液晶素子の透過光の位相分布は、液晶素子を透過する光路長で決まるので、液晶の厚み分布できまる。液晶の厚み分布は、透明基板の形状で決まるので、所望の位相分布に対する相似形状を透明基板の表面に形成することができれば、透過光に理想的な位相分布を与えることが可能となる。

【００５８】すなわち、本発明は、光源から発せられる光の損失を極力抑えつつ、光学素子の種々の製造誤差により発生する波面収差を良好に補正することができ、特に光学記録媒体の厚み誤差や傾き誤差などによる収差をも良好に補正することができる光学ピックアップ装置を提供することができるものである。

【図面の簡単な説明】

【図１】本発明に係る光学ピックアップ装置の構成を一部を破断して示す側面図である。

【図２】上記光学ピックアップ装置において収差補正を行う液晶素子の構成を示す縦断面図である。

【図３】上記液晶素子の構成を示す正面図である。

【図４】上記液晶素子の電圧を印加していない状態における要部の構成を示す縦断面図である。

【図５】上記液晶素子の電圧を印加している状態における要部の構成を示す縦断面図である。

【図６】上記液晶素子において印加電圧を調整して液晶層の屈折率をガラス基板の屈折率に等しくした状態における要部の構成を示す縦断面図である。

【図７】上記液晶素子において印加電圧を変化させて液晶層の屈折率をガラス基板の屈折率と異ならせた状態における要部の構成を示す縦断面図である。

【図８】球面収差により発生する波面を示すグラフであ

る。

【図９】コマ収差により発生する波面を示すグラフである。

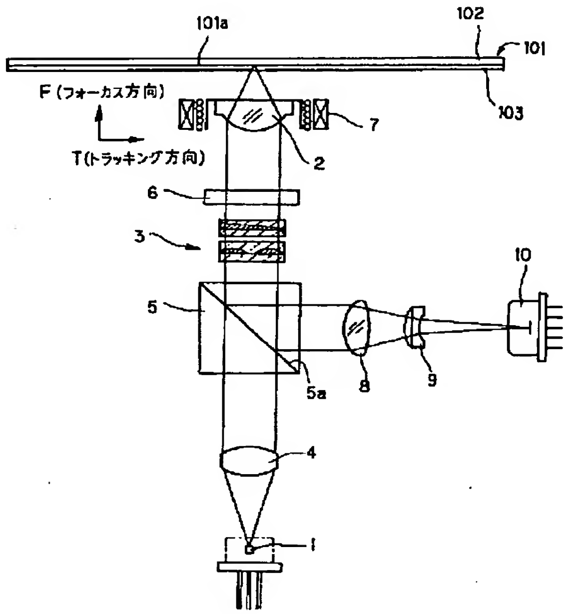
【図１０】球面収差を補正するための液晶素子の要部の形状を示す縦断面図である。

【図１１】コマ収差を補正するための液晶素子の要部の形状を示す縦断面図である。

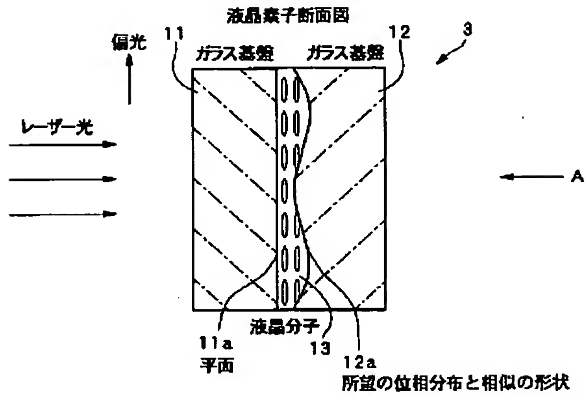
【符号の説明】

１　半導体レーザ、２　対物レンズ、３　液晶素子、１１，１２　ガラス基板、１３　液晶層、１４，１５　電極

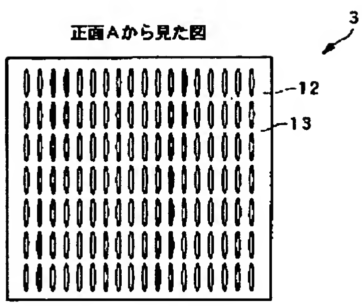
【図１】



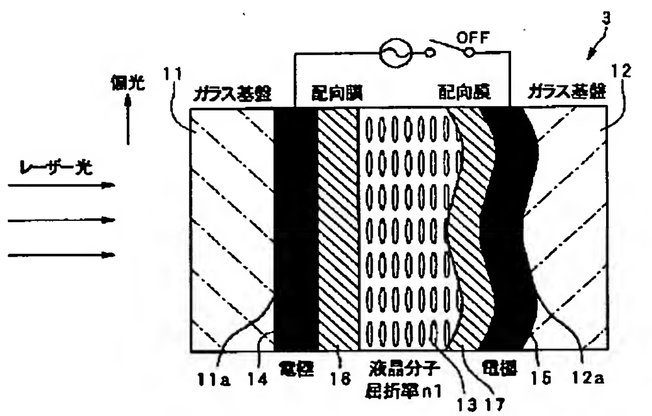
【図２】



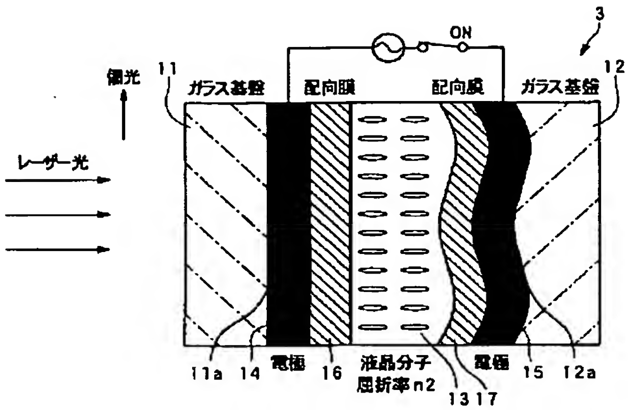
【図３】



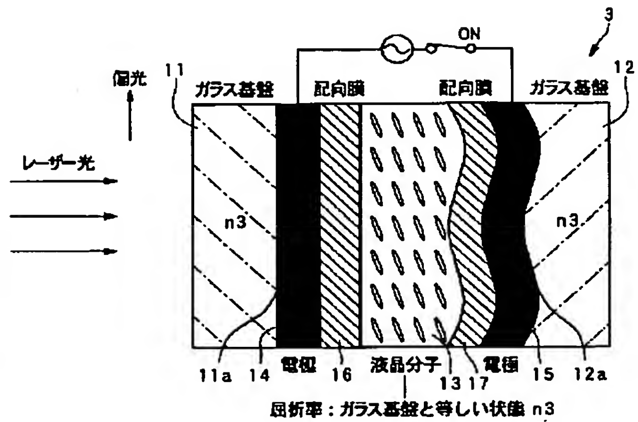
【図４】



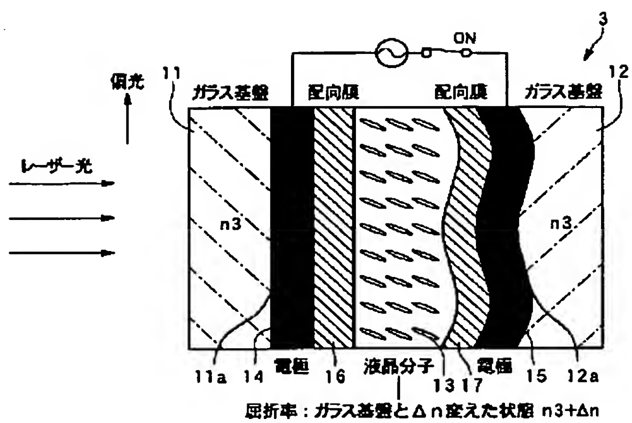
【図５】



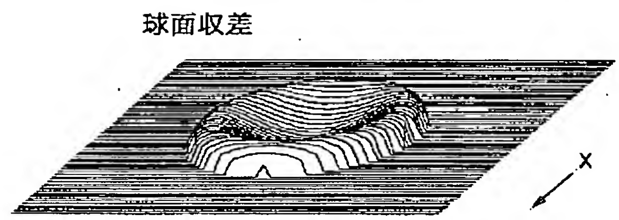
【図６】



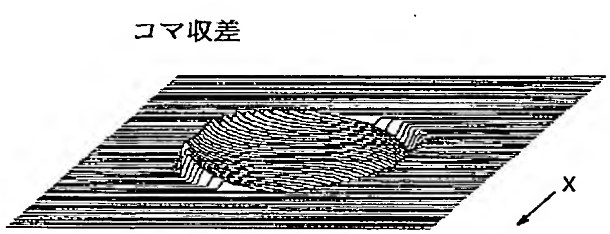
【図７】



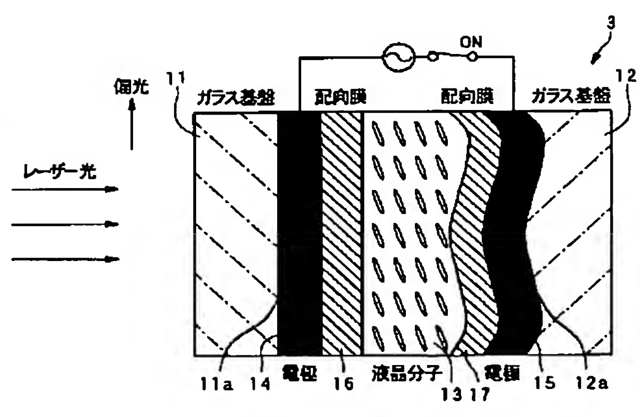
【図８】



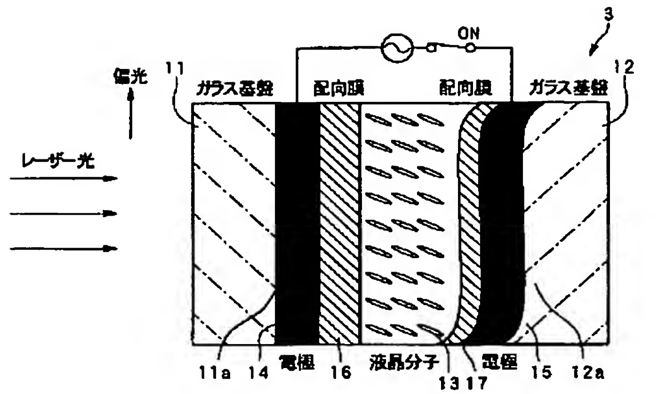
【図９】



【図１０】



【図１１】



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